Phase I Project Summary

Firm:Intelligent Automation Inc.
Contract Number: NNX11CG03P
Project Title: ESPRIT: Exercise Sensing and Pose Recovery Inference Tool

Identification and Significance of Innovation: (Limit 200 words or 2,000 characters whichever is less)

Intelligent Automation, Inc. (IAI) has developed algorithms for ESPRIT: Exercise Sensing and Pose Recovery Inference Tool, in support of NASA's effort in developing crew exercise technologies. ESPRIT is a stereo camera system that capture motion data of exercise activities of the crew. It does this by detecting and tracking reflective markers placed on the body or clothing and recovering 3D kinematic information of the body pose.

Crew exercise is important for maintaining the health and fitness of astronauts, to prevent adverse health problems associated with long-duration space flight, such as losses in bone density. These adverse effects could degrade their performance during space missions. Monitoring of crew health and fitness is therefore important. Commercial motion capture systems are bulky and require multiple cameras distributed around a large activity workspace and therefore not practical for spacecraft environment. A single-sensor motion capture system is therefore highly desirable.

ESPRIT relies on strong prior knowledge and modeling of human body, pose, dynamics, and appearance, and statistical inference techniques to achieve robust and accurate pose estimation. It is designed to meet the constraints in size, weight and power consumption imposed by the spacecraft environment

Technical Objectives and Work Plan: (Limit 200 words or 2,000 characters whichever is less)

The Phase I technical objectives are.
Objective 1: Software and hardware requirements and design of ESPRIT.
Objective 2: Knowledge base and model for pose and dynamics as prior models for pose estimation. Objective 3: Robust human pose estimation
Objective 4: Demonstration of the feasibility of ESPRIT.

The work plan includes the following tasks.
Task 1: Define system requirements for ESPRIT.
Task 2: Develop module for feature detection and tracking.
Task 3: Design module for pose estimation.
Task 4: Design framework for kinematic analysis.
Task 5: Develop Phase II and transition plans.

Technical Accomplishments: (Limit 200 words or 2,000 characters whichever is less)

IAI has made preliminary design of the ESPRIT system. Algorithms have been developed for marker detection and tracking, feature extraction, stereo matching of features, marker labeling

and pose estimation. A composite model has been developed to allow coarse-to-fine human body modeling and reconstruction. The model provides prior statistics on the human pose, shape, and dynamics in order to evaluate pose hypotheses accurately using a generative approach.

Experiments were conducted to demonstrate the feasibility of ESPRIT. The result has been promising. With a commercial stereo camera system, we have demonstrated the feasibility of the motion capture of several exercises, including treadmill walking, curling and dead lifting. For measuring relative locations of markers of a calibrated tool, an accuracy of about 10mm was achieved. With recommended changes in the hardware design, an accuracy of 5mm or less can be achieved. The accuracy will be improved further with proposed enhancement in algorithms in Phase II.

We have also developed the work plan for Phase II, which will focus on the development, demonstration, and delivery of ESPRIT prototype. C-Motion, Inc. will be a subcontractor in Phase II. They will assist IAI in data collection and performance evaluation, and in commercializing the ESPRIT technology as part of their motion capture software product.

NASA Application(s): (Limit 100 words or 1,000 characters whichever is less)

Crew exercise is important for maintaining health and fitness of astronauts, especially in preventing adverse health problems associated with long-duration space flight, such as losses in muscle strength and endurance, bone density, balance and aerobic capacity. The proposed ESPRIT system will support NASA's Exercise Countermeasure project for observing crew's exercise activities, performing motion capture and kinematic analysis, and will contribute towards the understanding the effect of microgravity in physical activities. ESPRIT is designed to satisfy the constraints in size, weight and power consumption

Non-NASA Commercial Application(s): (Limit 200 words or 2,000 characters whichever is less)

Non-NASA applications include uses in medicine and rehabilitation, such as gait analysis, orthopedics, and other applications for monitoring skeletal movement. Other applications include personal fitness and support of the aging, human-robotics and human-computer interaction, simulation, immersive reality, and video games. Potential customers include government research agencies such as Air Force Research Laboratory for human performance analysis and human factor engineering; National Institute of Health for rehabilitation research; physiotherapy clinics and nursing homes for patient monitoring, and sports equipment manufacturers for biomechanics studies. The development of a low cost motion capture system would open a wide range of opportunities in markets where conventional motion capture systems are too expensive.

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